



<p><b>Description</b> This activity is meant to extend your students' knowledge of the topics covered in our Simplicity of Electricity lab. Through this activity, your students will create a simplified version of the batteries used in everyday electronics.</p>		
<p><b>Grade Levels</b> 4-8 (<i>this activity is meant to be done in groups of 4-5 students</i>)</p>	<p><b>Student Outcomes</b> Students will:</p> <ul style="list-style-type: none"> <li>• Create a simple battery to power a light bulb.</li> </ul>	<p><b>Next Generation Science Standards</b></p> <ul style="list-style-type: none"> <li>• Physical Sciences: <b>Grade 4:</b> 4-PS3-2, 4-PS3-4; <b>Grade 5:</b> 5-PS1-3</li> <li>• Engineering and Design: <b>Grades 3-5:</b> 3-5-ETS1-3; <b>Grades 6-8:</b> MS-ETS1-1-4</li> </ul>
<p><b>Duration</b> 45 minutes</p>		<p><b>Common Core ELA Standards</b></p> <ul style="list-style-type: none"> <li>• <b>Grades 4-5:</b> Writing W.7; W.8</li> <li>• <b>Grade 4:</b> Speaking and Listening 4.SL.1b-d</li> <li>• <b>Grade 5:</b> Speaking and Listening 5.SL.1b-d</li> <li>• <b>Grades 6-8:</b> Writing W.7; Speaking and Listening SL.1b-e</li> </ul>

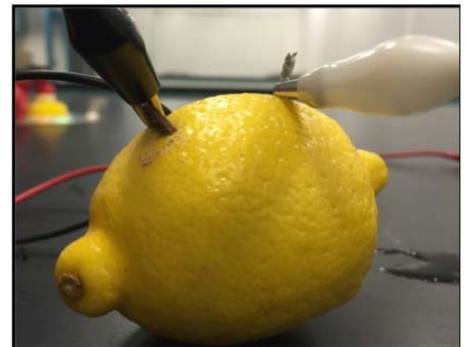
<p><b>Materials (one set per team of 4 students)</b></p> <ul style="list-style-type: none"> <li>• 2 lemons (room temperature)</li> <li>• Paper towels</li> <li>• 1 penny (pre-1982 if possible) or 4" length of copper wire</li> <li>• 1 galvanized nail or 3" zinc strip</li> <li>• Voltmeter (optional)</li> <li>• Alligator wires: <a href="http://www.frys.com/product/6469122?site=sr:SEARCH:MAIN_RSLT_PG">http://www.frys.com/product/6469122?site=sr:SEARCH:MAIN_RSLT_PG</a></li> <li>• Small LED's: <a href="http://www.frys.com/product/625972?site=sr:SEARCH:MAIN_RSLT_PG">http://www.frys.com/product/625972?site=sr:SEARCH:MAIN_RSLT_PG</a></li> </ul>
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<p><b>Vocabulary</b></p> <p><i>Familiarity with these terms and concepts will enhance students' experience in the activity.</i></p> <ul style="list-style-type: none"> <li>• <b>Conductor:</b> A material that allows electricity to flow through it easily.</li> <li>• <b>Insulator:</b> A material that does not allow electricity to flow through it easily.</li> <li>• <b>Electricity (from Greek, meaning "amber"):</b> Phenomena resulting from the presence and flow of electric charge; includes: lightning, static electricity, electromagnetic field, and electromagnetic induction.</li> <li>• <b>Electron:</b> Subatomic particle possessing a negative (-) electric charge.</li> <li>• <b>Battery:</b> A device that converts stored chemical energy into electrical energy.</li> </ul>
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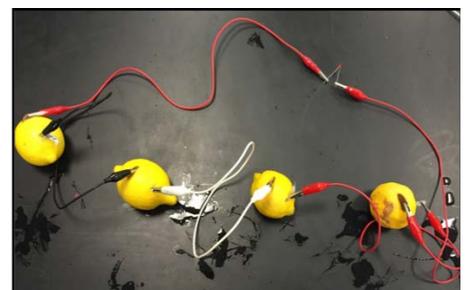
## Procedure

1. Each group should get one set of the above materials.
2. Begin with a discussion about batteries. What are they used for? How do you think they work?
  - a. Batteries are devices that store electrical energy in a chemical form. There are different chemicals inside the battery that allow it to generate electricity.
3. Before getting too much into how a battery works, each team will first create their lemon battery and then come back to the discussion.
4. To make the battery:
  - a. First, rub the lemon between your hands while gently squeezing. This will release more juices from the flesh making it more reactive for the battery.
  - b. Take the penny or copper wire and poke it through the skin of the lemon (into the flesh) on one side of the lemon. If using the penny, you (the teacher) may need to use a knife to cut a slit into the lemon rind for the penny to fit through. If using the wire, poke half of the length through the lemon.
  - c. Poke the nail through the rind on the opposite side of the lemon so that the penny or copper wire does not touch the nail inside the lemon.
  - d. The lemon battery is now ready to be used. Connect one alligator wire to the penny or copper wire and a second wire to the nail.
    - To light the bulb, connect each end of the bulb to the LED. If the light does not light up immediately, switch the bulb around (electricity can only flow through the bulb in one direction).
    - To test the voltage produced, use the voltmeter. Make sure the setting is at DCV 20.
    - Try adding more lights to the circuit. How many lights can be lit by one lemon?



## 5. Explanation:

- a. Batteries are composed of three things: an anode (the negative end—in the lemon battery it is the nail), a cathode (the positive end—the copper), and an electrolyte or acidic solution (lemon juice). When a battery is put into an electric circuit, a series of chemical reactions take place. During the chemical reactions, the reaction at the anode or negative end generates extra electrons, which want to go to the positive end of the battery but can't pass through the electrolyte. Electrons must travel around the outside of the battery through the circuit to reach the cathode or positive end of the battery. This flow of electrons is what generates the electricity to power your device.



## Extended Learning

- Try adding more lemons to the battery. Make sure that each lemon is set up the same as the first and then connect them positive to negative in a chain. Does adding more lemons to the chain increase the voltage? Why or why not? Can you power more lights with more lemons?
- Try using other metals as the anode and cathode. Some other possibilities include other coins, such as dimes, nickels and quarters. Which combinations work? Which don't? Why do you think some work and some don't?
- Try using other fruit as the source of the electrolyte. The solution must be acidic, so have students think of other fruits and vegetables that are acidic or that have been fermented (limes, oranges, grapefruit, pickles, sauerkraut, etc.). Which fruit or vegetable worked best? The worst?